BIOLOGICAL VALUE OF CASEIN AS A SUPPLEMENT TO THE PROTEINS OF BARLEY IN RATIONS FOR PIGS[1]

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INTRODUCTION

It has been shown at the California Agricultural Experiment Station by Thompson and Voorhies (*7*)[2] and by Hughes (*2*) that barley, when fed as the only source of protein, does not produce optimum growth in pigs. Protein-rich concentrates like fish meal and tankage or dairy byproducts when used as supplements to barley, produce more rapid growth. Such concentrates, however, contain other nutrients than protein, which makes it unsafe to conclude that the protein is responsible for the results obtained. Casein, since it has been used by biologists in similar studies with smaller animals than the pig, and since it is relatively low in cost, was used as a supplement in the studies reported here to determine whether or not the proteins of barley are present in amounts necessary for the rapid development of the pig.

EXPERIMENTAL DATA

In June 1929 two pigs about 50 pounds in weight, having free access to direct sunlight, were put on a diet of rolled barley, salt, and cod-liver oil. They grew very slowly and became stiff in the joints. Early in January of the following year calcium carbonate was added to the diet. At 1 year of age the pigs weighed only 162 pounds. It was believed that the diet was sufficient in all known factors for some growth, but the pigs had not gained in weight for some time. The only protein in the ration was that of barley. Casein was added to the diet and an immediate response was manifested by increase in weight, thrift, and appetite. During the following 3 months the pigs made an average daily gain of slightly more than 1 pound and became normal in health.

The results of this experiment were significant, but the number of animals used was too small to make possible any definite conclusions; therefore, a similar experiment on a larger scale was conducted in 1931–32. Two groups of eight pigs each were divided as nearly as possible into comparable lots. Each group was placed in a concrete lot with free access to direct sunlight, and the pigs were fed all they would consume of the following diets:

Group 1. Rolled barley, 98 percent; sodium chloride, 1 percent; calcium carbonate, 1 percent; and 5 cc of cod-liver oil each daily (basal diet).

Group 2. Rolled barley, 96.5 percent; sodium chloride, 1 percent; calcium carbonate, 1 percent; casein, 1.5 percent; and 5 cc of cod-liver oil each daily.

The results of this experiment are summarized in table 1.

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[2] Reference is made by number (italic) to Literature Cited, p. 465.

The average beginning and final weights were, for group 1, 23.3 and 94.6 pounds; and for group 2, 25.0 and 203.8 pounds. During the first part of the experiment the pigs fed casein (group 2) gained three times as fast and were more economical in their use of food than were the pigs fed protein supplied only by the barley (group 1). Each pound of casein fed to the animals in group 2 had a replacement value of 49.5 pounds of the basal feed. When casein was added to the diet of group 1, at both the 1.5- and 5-percent levels, there was an immediate response in increased appetite, rate of gain, and economy of feed utilization. The pigs did not gain as rapidly at either level as the pigs in group 2; however, they did consume less food for a unit of increase. It is postulated that this was due to a lower maintenance requirement because of a marked difference in the size of the pigs in both lots. When the casein level was increased to 5 percent the animals in both groups gained more rapidly and consumed less food for 100 pounds of gain than at any other time during the progress of the experiment, the protein level being apparently more nearly optimum for pigs at this stage of growth and development. The rate of gain in both groups was just about twice as rapid as when casein was fed at the 1.5-percent level.

TABLE 1.—*Summary of data from the second and third experiments to show the effect of adding casein to the basal diet of pigs when the sole other source of protein was barley*

Feeding period and diet	Group 1		Group 2	
	Average daily gain	Feed consumed per 100 pounds gain in weight	Average daily gain	Feed consumed per 100 pounds gain in weight
SECOND EXPERIMENT [1]				
	Pounds	*Pounds*	*Pounds*	*Pounds*
May 23 to Dec. 12, 1931 (group 1, basal diet: group 2, 1.5 percent casein added)	0.16	886.7	0.50	508.9
Dec. 12, 1931, to Jan. 23, 1932 (both groups, basal diet plus 1.5 percent casein)	.39	493.9	.77	529.9
Jan. 23 to Feb. 13, 1932 (both groups, basal diet plus 5 percent casein)	.88	310.0	1.45	339.3
Feb. 13 to Mar. 5, 1932 (both groups fed basal diet only)	.14	2,265.0	.74	711.3
THIRD EXPERIMENT [2]				
May 12 to Oct. 6, 1934 (group 1, basal diet; group 2, 1.5 percent casein added)	.36	577.6	.62	431.8
Oct. 6, 1934, to Jan. 10, 1935 (both groups, basal diet plus 1.5 percent casein)	1.20	[3] 445.1	1.37	438.9

[1] Groups of 8 pigs each.
[2] Groups of 10 pigs each.
[3] One pig was "off feed" for some time and died the day the experiment closed.

While the last period was only a short one, the results are significant because of the immediate decrease in daily gain by both groups and the large increase in food consumption required for a unit of increase in weight. The pigs in group 1 reverted to their original rate of gain, and while the pigs in group 2 were much larger and were fattening, their rate of increase dropped from 1.45 to 0.74 pounds per head daily.

A third experiment was conducted in 1934 to further check the results already obtained. This experiment was begun May 12, 1934,

and concluded January 10, 1935. Two groups of 10 pigs each were fed diets similar to those previously used. The average beginning weight for both groups was 29.6 pounds. The conditions of the experiment, including the grouping of the pigs and the size of the pens, were the same as before. To be sure that a lack of vitamin A would not influence the results, each pig in both groups was given 5 cc of cod-liver oil daily until July 21, and from that time until the experiment was concluded each was given 10 cc. The results are presented in table 1.

In this experiment the pigs were larger and thriftier at the beginning than those of the second experiment and were not fed so long in the first period, which may in part account for the difference in the rate of gain and the replacement value of the protein when the results are compared with those of the second experiment. Each pound of casein fed group 2 had a replacement value of 22.5 pounds in terms of food saved over that fed group 1. During the second phase of this experiment the pigs in both groups gained more rapidly than in the first period, which is in agreement with the results of the other experiments. While in some details the results of this test differed slightly from those of the preceding one, in principle they were the same.

In 1936 a fourth experiment was concluded which differed somewhat from those already reported. Osborne and Mendel (*3*) had reasoned that the failure of cereal proteins as they are generally fed is due to a lack of sufficient total cereal protein. In an effort to prove or disprove this theory and to obtain further information on the original subject, barley proteins fed group 1 were increased to a point in excess of that fed group 2, which received barley and casein. This was done by adding dried brewers' grains from which some of the hulls had been removed (the material removed was a mixture of hulls and some grain). Since the addition of dried brewers' grains to the diet of group 1 increased the fiber content, barley hulls were added to the mixture fed group 2 to make it comparable in this respect. The total crude protein fed groups 1 and 2 was respectively 11.12 and 10.42 percent. The fiber content of the ration fed to group 1 was 1 percent higher than that of the ration fed group 2. It is probable, however, that there was little difference in the amount of fiber consumed by the pigs in the two groups since those of group 1 left considerable quantities of hulls in the bottom of their feeder.

Since commercial casein contains lactoflavin, and the results of other experiments with hogs at this station (unpublished data had indicated that this factor is necessary for normal growth, it was deemed expedient to feed a third group of pigs casein washed free of this factor. The casein was washed by the method of Evans, Lepkovsky, and Murphy (*1*), modified by that of Supplee, Flanigan, Hanford, and Ansbacher (*6*).

The crude protein and fiber content of the diets fed groups 2 and 3 were the same.

The diets were:

Group 1. Rolled barley, 88 percent; brewers' grains (dried), 10 percent; sodium chloride, 1 percent; calcium carbonate, 1 percent; and 10 cc of cod-liver oil each weekly.

Group 2. Rolled barley, 91 percent; barley hulls, 5 percent; casein, 1.5 percent; sodium chloride, 1 percent; calcium carbonate, 1.5 percent; and 10 cc of cod-liver oil each weekly.

Group 3. The same as for group 2 except that the casein fed was washed free of lactoflavin.

The physical conditions of this experiment, including the grouping of the pigs and the size of the pens, were comparable to those of the other experiments. The experiment was begun June 6 and concluded October 31, 1936. There were eight pigs in groups 1 and 2 and five pigs in group 3.

TABLE 2.—*Summary of data from the fourth experiment to show the effect of adding commercial casein and casein washed free of lactoflavin to the basal diet of pigs when the sole other source of protein was barley*

[Experiment begun June 6 and concluded Oct. 31, 1936; 8 pigs in groups 1 and 2 and 5 in group 3]

Group no.	Average initial weight	Average daily gain	Feed consumed per 100 pounds gain in weight
	Pounds	*Pounds*	*Pounds*
1	39.3	0.61	383.0
2	38.8	1.12	320.4
3	34.4	.57	423.7

In this experiment as in the others the pigs fed casein (group 2) gained much faster and consumed less feed for 100 pounds of gain than those (group 1) fed only barley proteins, even though the total protein in the diet of group 1 was greater than that of group 2. In this case each pound of casein in the diet of group 2 had a replacement value of about 13 pounds of the diet fed group 1. However, if the results of this experiment are compared with those for animals fed only barley as shown in table 1, it will be found that the additional protein supplied by brewers' grain did result in increasing the daily gains and in decreasing the amount of feed required for 100 pounds of gain.

The pigs in group 3 (fed casein washed free of lactoflavin) gained no faster than the pigs of group 1 and consumed more feed for a unit of increase than either of the other groups.

DISCUSSION

In the experiments reported herein where the proteins of barley were the only source of protein for young growing pigs the rate of growth was slow. This agrees with the finding of Steenbock, Kent, and Gross (*5*) and with that of McCollum, Simmonds, and Parsons (*3*). Osborne and Mendel (*4*), however, reported that barley proteins are adequate as a whole in the nutrition of growth, and that several of their rats grew to large adult size without any other source of protein. The growth increase in their rats, however, was not consistent.

The addition of casein to the diet in the present experiments reduced considerably the amount of feed required for a unit increase in weight. Its value in replacing barley varied; however, 1 pound of casein supplanted more than 20 pounds of barley, except in the fourth experiment when it replaced about 13 pounds. In this case barley proteins were increased by the addition of dried brewers' grains to a point above that of the other group fed barley and casein. The results of these studies indicate that barley is deficient in some essential factor or factors necessary for normal growth and weight increase in the young pig.

That the total amount of protein in barley is probably a factor of importance is indicated by the fact that when dried brewers' grains were added to barley, thereby increasing the total barley proteins fed, the gains made were greater and the amounts of feed consumed for a unit of gain were smaller than when barley was fed alone.

Some uncertainty exists as to the reason for the beneficial effect of the addition of casein. The quantity of the protein and the lactoflavin content of the casein have been considered. Pigs fed unwashed commercial casein (group 2, experiment 4) gained twice as fast as pigs fed the same diet at the same time except that casein (from the same sack) washed free of lactoflavin was used.

SUMMARY

Young growing pigs fed a diet in which the proteins of barley were the only source of protein grew very slowly and required large quantities of feed for a unit of increase in weight.

When casein was added to such a diet there resulted a marked increase in rate of growth and a large reduction in feed required for an increase in body substance.

When the barley proteins in the diet were increased by the addition of dried brewers' grains, the gains were more rapid and the feed consumed for 100 pounds of gain were less than when only barley was fed.

The possibility that the lactoflavin in casein is responsible for its beneficial effect when added to barley is suggested.

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